Practice GEFS Model Guidance Scripts

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1. Raw Forecasts

- No bias correction/calibration
- The ensemble mean is the average of the 20 ensemble members
- Raw forecast anomalies are computed by removing model climatology from the ensemble mean forecast:

GEFS raw Forecast Anomaly = GEFS Ens. Mean – GEFS Model Climo

2. Post Processing

- The skill of NWP models decreases with forecast lead time.
  - Larger model errors for forecasts beyond week-2
- Among various post processing methods, we will take a look at two forecast error correction methods:
  - Bias correction
  - Ensemble regression calibration

3. Data

- For this tutorial, we have provided observation and Forecast data.
- Observation Data:
  - 20 years (1999-2018) CPC Blended rainfall for week-1/2 target periods
  - 20 years (1999-2018) CPC Gridded 2m Temperature for the week-1/2 target periods

3. Data (cont.)

- Reforecast and Forecast Data:
  - 20 years (1999-2018) GEFS Reforecast of rainfall for week-1/2 target periods
  - 20 years (1999-2018) GEFS Reforecast of 2m temperature for week-1/2 target periods
  - GEFS real-time (2019) forecasts with 20 ensemble members

4. Bias Correction Method (linear bias assumed)

- Bias for a given period i in the past is defined as:

$$\mathbf{bi = fi - oi}$$

where f stands for forecast and o stands for observation.

- In this tutorial we compute two biases:
  - Average Bias (b30) over previous 30 days (prior to the week -1/2 forecast period) > 30 biases
  - Hindcast period (1999-2018) bias (b20) for the week-1 /2 target periods > 20 biases

4. Bias Correction Method (cont.)

- We then compute the average of these two biases

avbias = (b30 + b20) /2

- We use this average bias value to correct our raw ensemble mean raw forecast

bias corrected forecast = raw forecast – avbias

Where raw forecast is the original model rainfall or 2m temperature forecast, valid: 26 Feb - 4 Mar, 2019 (week 1) and 5 – 11 March, 2019 (week 2).

5. Regression Calibration Method

- Linear Regression

$$y = mx + b$$

- Where y is forecast anomaly, and x is observation anomaly

- We have the reforecast and observation data for the hindcast period (1999 – 2018)
- Use observation and reforecast dataset to calculate the regression coefficients (m and b)
- Use the regression coefficients to calibrate your raw forecast

5. Regression Calibration Method (cont.)

- Prepare your observation and model climatology:
  - Using the rainfall and temperature observation data, compute rainfall and 2m temperature observation climatology for the target periods, 26 Feb - 4 Mar, 2019 (week 1) and 5 – 11 March, 2019 (week 2).
  - You will have two types of climatological values for rainfall:
    - **Regular climatology** (the sum of observations divided by the number of years)
    - **Transformed climatology** (the fourth root of your regular climatology). The transformation is required to ensure normal distribution in the rainfall data
    - No need of transformation for temperature data
  - Using the rainfall and temperature Reforecast data, compute rainfall and 2m temperature model climatology for the target period, 26 Feb - 4 Mar, 2019 (week 1) and 5 – 11 March, 2019 (week 2).
  - As in the observed climatology, you should have two climatological values (**regular and transformed**) rainfall model climatology, and one 2m temperature model climatology

5. Regression Calibration Method (cont.)

- Prepare your hindcast observation Anomaly:
  - For each year in the hindcast period (1999-2018), transform your rainfall observation using the fourth root approach to ensure normality in your data

$$\textbf{TarnsformedRainfallObservation}^{i} = \textbf{sqrt(sqrt(RegularRainfallObservation}^{i}\textbf{)}$$

Where i varies from year 1 to 20 (1999 – 2018)

  - Using your transformed rainfall observation and transformed rainfall climatology, compute transferred rainfall anomaly for each year in the hindcast period:

$$\textbf{RainfallTarnsformedAnomaly}^{i} = \textbf{RainfallTarnsformedObservation}^{i} - \textbf{RainfallRarnsformedClimatology}$$

  - Using your regular 2m temperature observation and climatology, compute observation anomaly for each year in the hindcast period:

$$\textbf{TempratureAnomaly}^{i} = \textbf{TempratureObservation}^{i} - \textbf{TemperatureClimatology}$$

5. Regression Calibration Method (cont.)

- Prepare your hindcast Reforecast anomaly:
  - For each year in the hindcast period (1999-2018), transform your rainfall forecast using the fourth root approach to ensure normality in your data

$$\textbf{TarnsformedRainfallCFS}^{i} = \textbf{sqrt(sqrt(RegularRainfallCFS}^{i}\textbf{)}$$

Where i varies from year 1 to 20 (1999 – 2018)

  - Using your transformed rainfall forecast and transformed CFS climatology, compute transferred Forecast anomaly for each year in the hindcast period:

$$\textbf{GEFSRainfallTarnsformedAnomaly}^{i} = \textbf{GEFSRainfallTarnsformedForecast} - \textbf{GEFSRainfallTrarnsformedClimatology}$$

  - Using your regular 2m temperature Forecasts and model climatology, compute forecast anomaly for each year in the hindcast period:

$$\textbf{GEFSTempratureAnomaly}^{i} = \textbf{GEFSTempratureForecast}^{i} - \textbf{GEFSTemperatureClimatology}$$

5. Regression Calibration Method (cont.)

- Compute the statistics required for regression calibration:
  - Using your transformed rainfall observation anomalies and transformed rainfall forecast anomalies, compute time correlation over the hindcast period (1999 – 2018)
  - Using your transformed rainfall observation anomalies, compute standard deviation of the observed rainfall anomalies
  - Using your 2m temperature observation anomalies and 2m temperature forecast anomalies, compute time correlation over the hindcast period (1999 – 2018)
  - Using your temperature observation anomalies, compute standard deviation of the observed temperature anomalies
  - Using your transformed rainfall forecast anomalies, compute standard deviation of the forecast rainfall anomalies
  - Using your temperature forecast anomalies, compute standard deviation of the forecast temperature anomalies

5. Regression Calibration Method (cont.)

- Compute statistics required for regression calibration:
  - Using your computed correlation, observation standard deviation and forecast standard deviation, compute regression coefficients for temperature and rainfall, separately:

    RegCoef = Correlation * (Observation StdDevn/Forecast StdDevn)

5. Regression Calibration Method (cont.)

- Prepare your Real-Time 2m Temperature and rainfall forecasts:
  - Using the GEFS 20 ensemble member forecasts in your real-time forecast, compute ensemble mean 2m Temperature and Rainfall forecasts, valid 26 Feb - 4 Mar, 2019 (week 1) and 5 – 11 March, 2019 (week 2)..
  - Compute Uncorrected Temperature and Rainfall Forecast Anomaly

UncorrectedTemperatureAnomaly = UncorrectedTemperatureFcst – GEFSTemperatureClimatology

UncorrectedRainfallAnomaly = UncorrectedRainfallFcst - GEFSRainfalllimatology

5. Regression Calibration Method (cont.)

- Compute your Corrected Forecasts:
  - Using uncorrected forecasts, regression Coefficient and standard deviation of observation, compute corrected forecasts:
  - For rainfall:

RainfallCorrectedForecast = (RainfallRegCoef * TransformedRainfallUncorrectedAnomaly) / RainObservationStdDevn

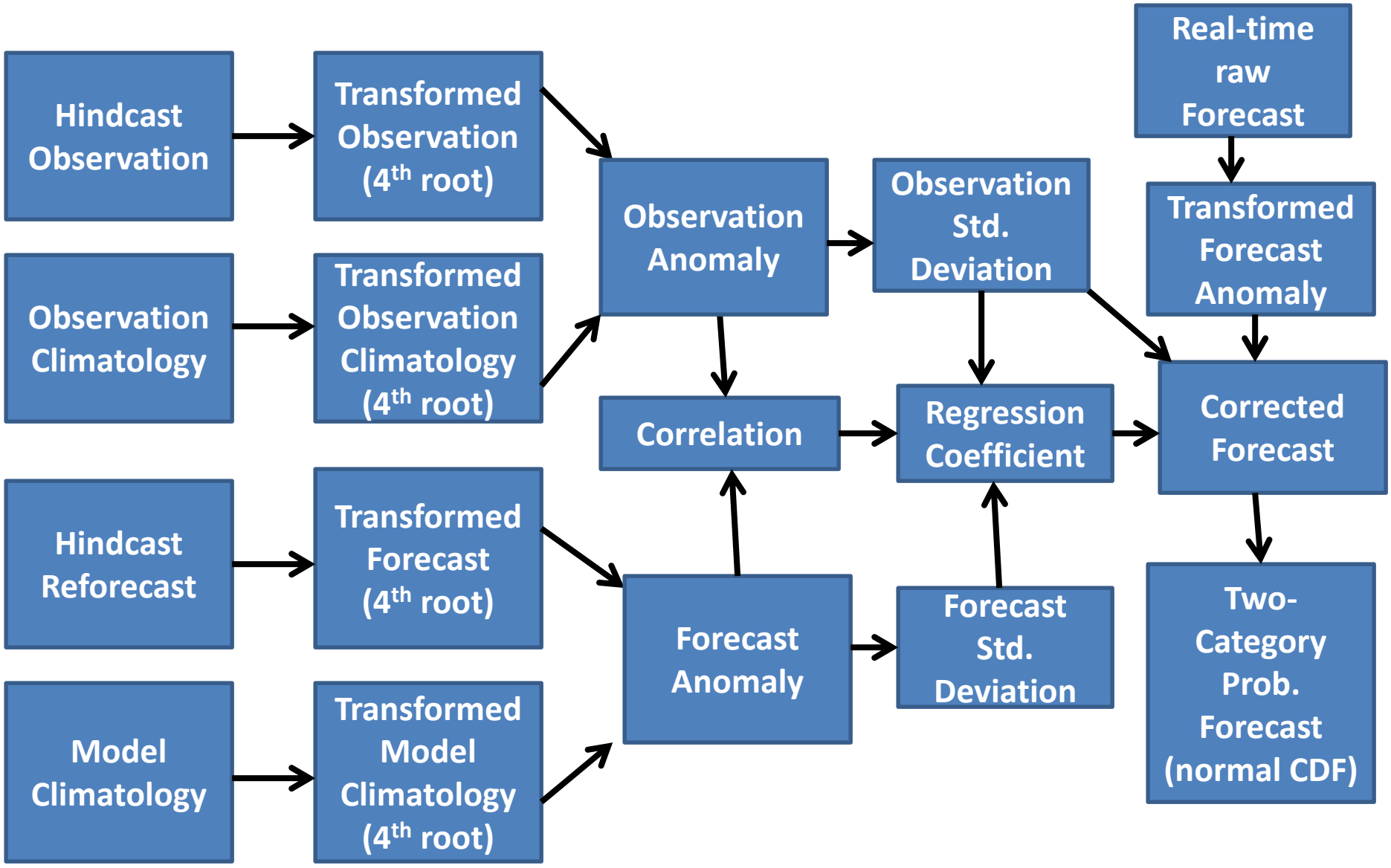
  - For Temperature:

TemperaturelCorrectedForecast = (TemperaturelRegCoef * TemperatureUncorrectedAnomaly) / TempObservationStdDevn

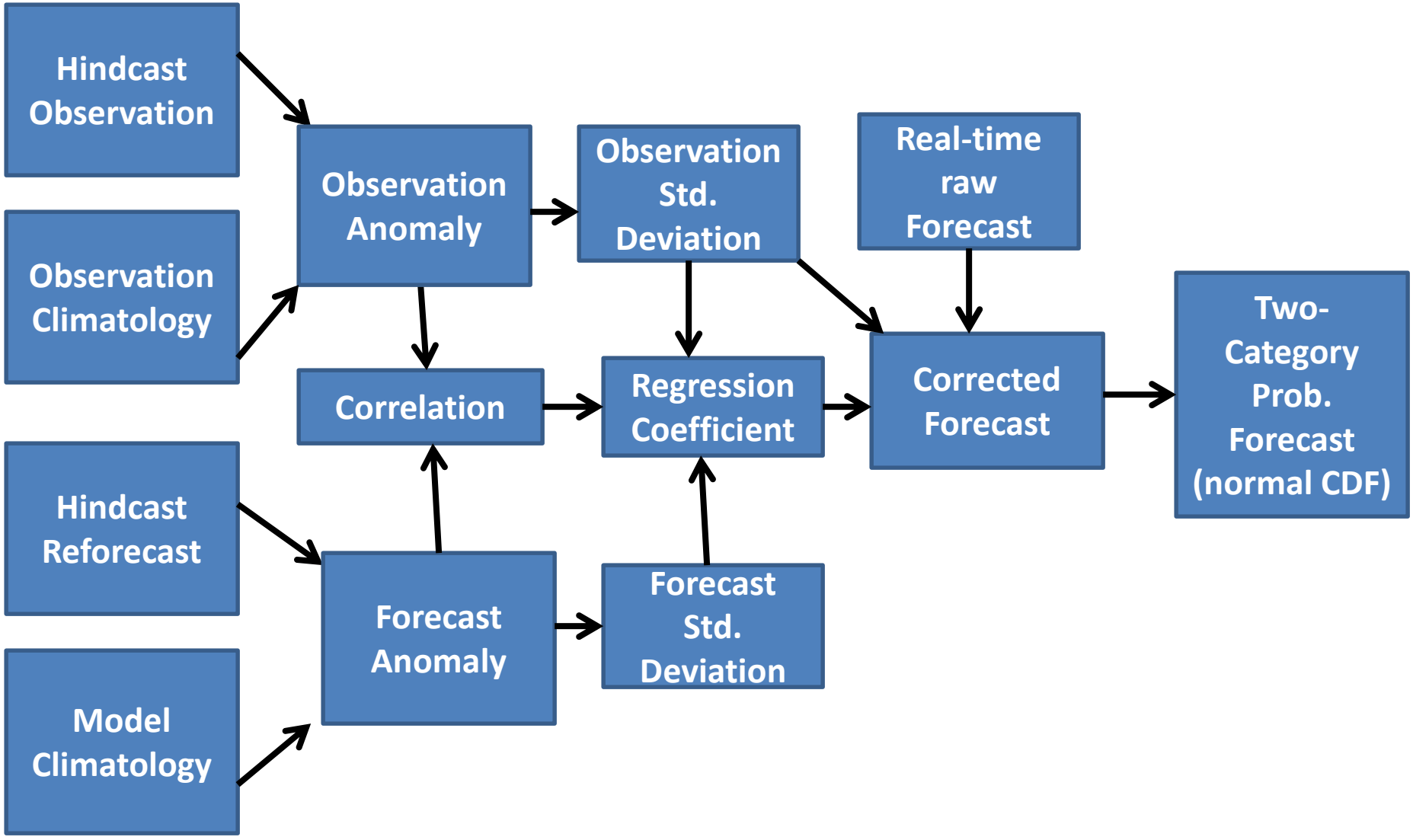
5. Regression Calibration Method (cont.)

- For Raw (uncorrected) forecasts, compute the probability of above-average by counting the proportion of ensemble forecasts that exceed climatological values.
- Similarly, for Bias corrected forecasts, count the proportion of ensemble members that exceed climatological values to get probability of above-average
- For Regression Calibration forecasts, using the corrected forecasts and associated statistics, and using the cumulative distribution function, obtain the above-average exceedance probability
- In two category forecasts, probability of below-average is 1 – probability of above-average

6. Ensemble Regression Calibration Process - Rainfall



7. Ensemble Regression Calibration Process – 2m Temperature



8.Post Processing Using GrADS

- GrADS post processing scripts are provided along with observation and forecast data.
  - From your home directory, uncompress the compressed file, by typing:

  tar –xvf subseason_with_grads.tar.gz
  - Change your directory by typing:

  cd subseason_with_grads
  - Move to another sub-directory by typing:

  cd week1and2diagnostics/
  - This directory contains all the required data and scripts for this exercise
  - Move to another subfolder by typing:

  cd scripts/
  - Type **ls** to see the content of this subfolder
  - You should see 5 GrADS scripts (with gs extension)

8.Post Processing Using GrADS (cont.)

- Take a look at files in the this sub-folder. Most of the file names are self-explanatory.
- Using any text editor (npp or gedit), you may open the GrADS script files

For example you may type:

npp calibrated_bias_corrected_and_raw_gefs_precip_week1.gs &

gedit calibrated_bias_corrected_and_raw_gefs_precip_week1.gs

- Take a look at the contents. Description was provided for most in these scripts, and are easy to understand.

9. Plot Week-1 Circulation Anomalies Using GrADS

- Before running the GrADS scripts, you need to set domain for your area of interest:
- For week-1 circulation anomalies, open GrADS script using your text editor (gedit or npp)

npp gefs_week1_circulation_anomalies.gs

gedit gefs_week1_circulation_anomalies.gs

- On the top of the file, you need to change latitude and longitude values to reflect your area of interest (the default area is Africa)
- After setting your domain, save and exit
- From your Cygwin/linux terminal run the script using the command below:

grads –pc gefs_week1_circulation_anomalies.gs

opengrads –pc gefs_week1_circulation_anomalies.gs

- This should generate 850-hPa and 200-hPa wind and divergence anomalies for the week-1 target period (Feb 26 – Mar 4, 2019).
- Type **quit** to exit from GrADS

10. Plot Week-1 raw, bias corrected and calibrated rainfall forecasts Using GrADS

- Set your domain:

npp calibrated_bias_corrected_and_raw_gefs_precip_week1.gs
gedit calibrated_bias_corrected_and_raw_gefs_precip_week1.gs

- On the top of the file, you need to change latitude and longitude values to reflect your area of interest (the default area is Africa)

- After setting your domain, save and exit

- From your Cygwin/linux terminal run the script using the command below:

grads –pc calibrated_bias_corrected_and_raw_gefs_precip_week1.gs
opengrads calibrated_bias_corrected_and_raw_gefs_precip_week1.gs

- This should generate raw, bias corrected and calibrated rainfall forecasts for the week-1 target period (Feb 26 – Mar 4, 2019).

11.Plot Week-1 Exceedance Probability Plots Using GrADS

- Set your domain:

npp gefs_week1_precip_exceedance_prob.gs

gedit gefs_week1_precip_exceedance_prob.gs

- On the top of the file, you need to change latitude and longitude values to reflect your area of interest (the default area is Africa)

- After setting your domain, save and exit

- From your Cygwin/linux terminal run the script using the command below:

grads –pc gefs_week1_precip_exceedance_prob.gs

Opengrads –pc gefs_week1_precip_exceedance_prob.gs

- This should generate exceedance probability plots for 25, 50, 75 and 100 mm per week plots for the week-1 target period (Feb 26 – Mar 4, 2019).

Exercise

- Run circulation and rainfall anomaly as well as exceedance probability scripts for week 2
- Remember to set your domain
- Use the images generated from week-2 scripts, together with the MJO information discussed in the morning, create a week-2 diagnostic ppt for your area of interest.